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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : D04H 1/54, 1/60, A61F 13/15 | A1

(11) International Publication Number: WO 98/24960

(43) International Publication Date: 11 June 1998 (11.06.98)

(21) International Application Number: PCT/US97/23152

(22) International Filing Date: 5 December 1997 (05.12.97)

(30) Priority Data:
60/032,794 6 December 1996 (06.12.96) US

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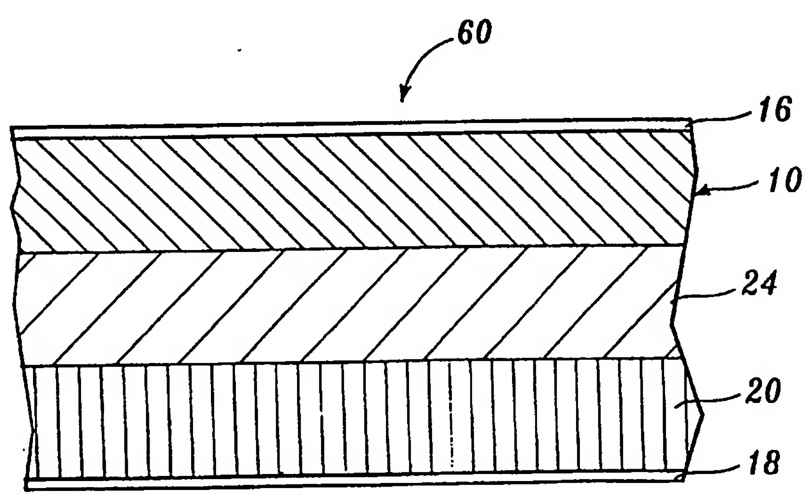
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: AIR-LAID UNITARY ABSORBENT LAYER



(57) Abstract

An air-laid unitary absorbent layer composed of crosslinked cellulosic fibers and a binder is disclosed. In a preferred embodiment, the binder is a bicomponent binding fiber. In combination with one or more other layers in an absorbent article, the unitary absorbent layer can rapidly acquire, distribute, temporarily store, and then release the acquired liquid to other liquid retention layers. A method for forming the unitary absorbent layer is also disclosed.

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AIR-LAID UNITARY ABSORBENT LAYER

Field of the Invention

The present invention relates to an absorbent layer and methods for making the same and, more particularly, to an air-laid unitary absorbent layer.

Background of the Invention

Cellulose fibers derived from wood pulp are used in a variety of absorbent articles, for example, diapers, incontinence products, and feminine hygiene products. It is desirable for the absorbent articles to have a high absorbent capacity for liquid, as well as to have good strength characteristics for durability. In addition to absorbent capacity, the ability to rapidly absorb a liquid is a desirable characteristic of an absorbent article. For example, diapers and other hygienic products that do not contain a dedicated liquid acquisition component suffer from measurable urine containment problems as well as rewet, that is, the feeling of dampness to touch after use.

One solution to the problem of providing absorbent articles that possess the advantageous properties of high absorbent capacity, rapid liquid acquisition, and superior rewet performance has been the production of absorbent articles that combine an acquisition layer with one or more other layers. For example, the combination of one layer having rapid liquid acquisition characteristics with another layer having high absorbent capacity results in a product that offers the advantages of both layers.

A recognized problem with conventional acquisition layers is their tendency to collapse upon wetting. Such a wet collapse impairs the permeability of the structure and can result in liquid leakage from the absorbent article.

Another recognized problem with cellulosic-based acquisition layers that are air laid on diaper lines is their relatively poor dry and wet integrity. Upon movement and/or wetting, the acquisition layers can crack, bunch, and disintegrate, all of which adversely affect fluid transfer between the layers and significantly impact the layer's fluid-handling capability. Furthermore, consumers react negatively to bunched diapers.

It has also been recognized that forming fibrous webs that contain high levels of crosslinked cellulosic fibers and/or in combination with synthetic fibers is difficult because of the flocculent nature of the fibers. In addition, due to the low density of the fibers, large quantities of such webs having appreciable roll life for diaper line production are difficult to provide.

Accordingly, there exists a need for an acquisition layer that can be incorporated into an absorbent article that has enhanced dry and wet integrity, increased resistance to wet collapse, and provides increased permeability and porosity to effect the rapid acquisition and distribution of acquired liquid and improved rewet performance. A need also exists for delivering such a material in a form which reduces the material handling problems associated with bulky webs. The present invention seeks to fulfill these needs and provides further related advantages.

Summary of the Invention

The present invention is an air-laid unitary absorbent layer that includes a fibrous material and a binder. In a preferred embodiment, the absorbent layer includes a thermally bonded mixture of crosslinked cellulose fibers and multicomponent binding fibers. In combination with one or more other layers in an absorbent article, the unitary absorbent layer can rapidly acquire, distribute, temporarily store, and then release the acquired liquid to other liquid retention layers.

Brief Description of the Drawings

The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same becomes better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a schematic view of one absorbent article incorporating an unitary absorbent layer produced in accordance with the present invention;

FIGURE 2 is a schematic view of another absorbent article incorporating an unitary absorbent layer produced in accordance with the present invention;

FIGURE 3 is a schematic view of still another absorbent article incorporating an unitary absorbent layer produced in accordance with the present invention;

FIGURE 4 is a schematic view of yet another absorbent article incorporating an unitary absorbent layer produced in accordance with the present invention; and

FIGURE 5 is a schematic view of another absorbent article incorporating an unitary absorbent layer produced in accordance with the present invention.

Detailed Description of the Preferred Embodiment

In one aspect, the present invention provides an air-laid unitary absorbent layer that includes a fibrous material and a binder. Generally, the fibrous material includes one or more hydrophilic fibers and, optionally, additional fibers such as hydrophobic fibers including synthetic fibers. The unitary absorbent layer of this invention has increased wet and dry integrity and improved pore size uniformity compared to conventional acquisition layers. The unitary absorbent layer of the present invention can be incorporated into a variety of absorbent products and articles to increase the liquid acquisition rate, improve the rewet performance, and enhance the wet and dry integrity of the absorbent article. Thus, the unitary absorbent layer is an absorbent layer that is useful as an acquisition layer in absorbent products.

In another aspect of the present invention, a method for producing an air-laid unitary absorbent layer is provided.

In addition to serving as an acquisition layer that can rapidly acquire fluid and reduce rewet, because of increased permeability and pore size uniformity, the unitary absorbent layer of the invention can also serve as a distribution layer that transports liquid from the site of insult throughout the composite, and then ultimately to a highly absorbent core or permanent retention layer. Furthermore, because of the substantial absorbent capacity of the composite's fibrous material, the unitary absorbent layer can also serve as a storage layer. Thus, when configured in combination with other layers in an absorbent construct, the unitary absorbent layer serves as a temporary storage layer that can rapidly release liquid to other core or retention layers. As used herein, the term "temporary storage" refers to the ability of a material to temporarily provide holding capacity for a liquid until an external force drains the fluid from the material. The external force can be, for example, greater capillary pressure or otherwise exerted by an adjacent storage layer.

Generally, the unitary absorbent layer of the present invention includes a fibrous material in combination with a binder. As used herein, the term "fibrous material" refers to any material that includes one or more hydrophilic fibers and, optionally, additional fibers such as hydrophobic fibers including synthetic fibers. Synthetic and/or hydrophobic fibers can also be included in the absorbent layer provided that the overall composite remains relatively hydrophilic and maintains the advantageous properties of wet integrity and permeability characteristic of the unitary absorbent layer of the present invention. In a preferred embodiment, the hydrophilic fibers include cellulosic fibers, and more preferably crosslinked cellulosic fibers. Suitable and preferred cellulosic fibers are described below. Generally, the fibrous material is present in the layer in an amount ranging from about 5 to about 95% by weight of the total layer. Preferably, the fibrous material is present in the absorbent layer in an amount ranging from about 70% to about 90%, and more preferably about 80%, by weight of the total layer.

In addition to the cellulosic fibers noted above, synthetic fibers can also be included in the unitary absorbent layer of the present invention. Suitable synthetic fibers include, for example, polyethylene terephthalate (PET), polyethylene, polypropylene, nylon, and rayon fibers.

For the unitary absorbent layers of this invention that include synthetic fibers, the performance of the composite has been found to be dependent upon a number of factors including the length, denier (g/m), and physical nature of the synthetic fibers. Suitable synthetic fibers useful in forming the layer can have a length up to about 0.75 inch, and preferably have a length between about 0.25 and about 0.5 inch. Suitable fibers include fibers having denier up to about 40 denier, and preferably between about 5 and about 20 denier. While straight fibers can be advantageously used in the formation of the layer, in a preferred embodiment, the fibers are crimped.

Cellulosic fibers are a basic component of the unitary absorbent layer of with the present invention. Although available from other sources, cellulosic fibers are derived primarily from wood pulp. Suitable wood pulp fibers for use with the invention can be obtained from well-known chemical processes such as the Kraft and sulfite processes, with or without subsequent bleaching. The pulp fibers may also be processed by thermomechanical, chemithermomechanical methods, or combinations thereof. The preferred pulp fiber is produced by chemical methods. Ground wood fibers, recycled or secondary wood pulp fibers, and bleached and unbleached wood pulp fibers can be used. The preferred starting material is prepared from long fiber

coniferous wood species, such as southern pine, Douglas fir, spruce, and hemlock. Details of the production of wood pulp fibers are well-known to those skilled in the art. These fibers are commercially available from a number of companies, including Weyerhaeuser Company, the assignee of the present invention. For example, suitable cellulose fibers produced from southern pine that are usable with the present invention are available from Weyerhaeuser Company under the designations CF416, NF405, PL416, FR516, and NB416.

The wood pulp fibers useful in the present invention can also be pretreated prior to use with the present invention. This pretreatment may include physical treatment, such as subjecting the fibers to steam, or chemical treatment, for example, crosslinking the cellulose fibers using any of a variety of conventional crosslinking agents such as dimethyldihydroxyethyleneurea. Crosslinking the fibers, for example, increases their resiliency, and thereby can improve their absorbency. The fibers may also be twisted or crimped, as desired. Suitable crosslinked cellulose fibers produced from southern pine are available from Weyerhaeuser Company under the designation NHB416. Crosslinked cellulose fibers and methods for their preparation are disclosed in U.S. Patent No. 5,225,047, issued July 6, 1993, entitled "Crosslinked Cellulose Products and Method For Their Preparation," expressly incorporated herein by reference.

Although not to be construed as a limitation, examples of pretreating fibers include the application of fire retardants to the fibers, and surfactants or other liquids, such as water or solvents, which modify the surface chemistry of the fibers. Other pretreatments include incorporation of antimicrobials, pigments and densification or softening agents. Fibers pretreated with other chemicals, such as thermoplastic and thermosetting resins also may be used. Combinations of pretreatments also may be employed. Similar treatments can also be applied after the composite formation in post-treatment processes.

Cellulosic fibers treated with particle binders and/or densification/softness aids known in the art can also be employed in accordance with the present invention. The particle binders serve to attach other materials, such as cellulosic fiber superabsorbent polymers as well as others, to the cellulosic fibers. Cellulosic fibers treated with suitable particle binders and/or densification/softness aids and the process for combining them with cellulose fibers are disclosed in the following U.S. patents and patent applications: (1) Patent No. 5,543,215, entitled "Polymeric Binders for Binding Particles to Fibers"; (2) Patent No. 5,538,783, entitled "Non-Polymeric

Organic Binders for Binding Particles to Fibers"; (3) Patent No. 5,300,192, entitled "Wet Laid Fiber Sheet Manufacturing With Reactivatable Binders for Binding Particles to Binders;" (4) Patent No. 5,352,480, entitled "Method for Binding Particle to Fibers Using Reactivatable Binders"; (5) Patent No. 5,308,896, entitled "Particle Binders for High-Bulk Fibers"; (6) Serial No. 07/931,279, filed August 17, 1992, entitled "Particle Binders that Enhance Fiber Densification"; (7) Serial No. 08/107,469, filed August 17, 1993, entitled "Particle Binders"; (8) Serial No. 08/108,219, filed August 17, 1993, entitled "Particle Binding to Fibers"; (9) Serial No. 08/107,467, filed August 17, 1993, entitled "Binders for Binding Water Soluble Particles to Fibers"; (10) Patent No. 5,547,745, entitled "Particle Binders"; (11) Serial No. 08/108,218, filed August 17, 1993, entitled "Particle Binding to Fibers"; and (12) Patent No. 5,308,896, entitled "Particle Binders for High-Bulk Fibers," all expressly incorporated herein by reference. One example of a suitable densification/softness aid is a mixture of 70% sorbitol and 30% glycerin. The composite is treated with sorbitol and glycerin by spraying the composite with the mixture and passing the composite through a roll coater, or other means of adding a liquid to a composite familiar to those skilled in the art.

Materials that enhance absorbent capacity, such as superabsorbent polymers, can also be combined with the unitary absorbent layer of the present invention. A superabsorbent polymer as used herein is a polymeric material that is capable of absorbing large quantities of fluid by swelling and forming a hydrated gel (hydrogel). The superabsorbent polymers also can retain significant amounts of bodily fluids under moderate pressures. Superabsorbent polymers generally fall into three classes, namely, starch graft copolymers, crosslinked carboxymethylcellulose derivatives and modified hydrophilic polyacrylates. Examples of such absorbent polymers are hydrolyzed starch-acrylonitrile graft copolymer, a neutralized starch-acrylic acid graft copolymer, a saponified acrylic acid ester-vinyl acetate copolymer, a hydrolyzed acrylonitrile copolymer or acrylamide copolymer, a modified crosslinked polyvinyl alcohol, a neutralized self-crosslinking polyacrylic acid, a crosslinked polyacrylate salt, carboxylated cellulose, and a neutralized crosslinked isobutylene-maleic anhydride copolymer. The superabsorbent polymeric materials can be combined with the layer's fibers in amounts up to about 5%, and preferably about 2%, by weight based on the total weight of the layer.

Superabsorbent polymers are available commercially, for example, starch graft polyacrylate hydrogel fines from Hoechst-Celanese of Portsmouth, Virginia. These

superabsorbent polymers come in a variety of sizes, morphologies and absorbent properties. These are available from Hoechst-Celanese under trade designations such as IM 1000 and IM 3500. Other superabsorbent particles are marketed under the trademarks SANWET (supplied by Sanyo Kasei Kogyo Kabushiki Kaisha), SUMIKA GEL (supplied by Sumitomo Kagaku Kabushiki Kaisha), which is suspension polymerized and spherical, as opposed to solution polymerized ground particles, FAVOR (supplied by Stockhausen of Greensboro, North Carolina), and NORSOCRYL (supplied by Atochem). Other superabsorbent polymers are described in U.S. Patent No. 4,160,059; U.S. Patent No. 4,676,784; U.S. Patent No. 4,673,402; U.S. Patent No. 5,002,814; U.S. Patent No. 5,057,166; U.S. Patent No. 4,102,340; and U.S. Patent No. 4,818,598, expressly incorporated herein by reference. Products such as diapers that incorporate superabsorbent polymers are shown in U.S. Patent No. 3,669,103 and U.S. Patent No. 3,670,731.

The unitary absorbent layer of the present invention is formed by combining a fibrous material (i.e., one or more hydrophilic fibers optionally in combination with one or more hydrophobic and/or synthetic fibers) with a binder. As used herein, the term "binder" refers to a system that is effective in intertwining and/or bonding the fibers to each other and/or the fibers of the binder. Suitable binders include bonding agents such as thermoplastic and thermosetting bonding agents, and soluble bonding mediums used in combination with solvents. Alternatively, the absorbent layer's hydrophilic fibers can be intertwined and/or bonded through a mechanical process including, for example, hydroentanglement, embossing, tenderizing, and needling processes.

Suitable binders include bonding agents, such as cellulosic and synthetic fibrous materials, and soluble bonding mediums as described below. In one preferred embodiment, the binder is a synthetic fibrous material, such as Celbond® (Hoechst Celanese) and D-271P® (DuPont). In another preferred embodiment, the binder includes a soluble bonding medium, more preferably cellulose acetate used in combination with the solvent triacetin. Generally, the binder is included in the composite in an amount up to about 30%, and preferably about 20%, by weight of the total composite.

Bonding agents useful in the binder in accordance with the present invention are those materials that (a) are capable of being combined with and dispersed throughout a web of cellulosic fibers, (b) when activated, are capable of coating or otherwise adhering to the fibers or forming a binding matrix, and (c) when

deactivated, are capable of binding at least some of the fibers together. The use of bonding agents with cellulose fiber webs is disclosed in U.S. patent application Serial No. 08/337,642, filed November 10, 1994, entitled "Densified Cellulose Fiber Pads and Methods of Making the Same," expressly incorporated herein by reference.

Suitable bonding agents include thermoplastic materials that are activated by melting at temperatures above room temperature. When these materials are melted, they will coat at least portions of the cellulose fibers with which they are combined. When the thermoplastic bonding agents are deactivated by cooling to a temperature below their melt point, and preferably no lower than room temperature, the bonding agent will upon solidifying from the melted state cause the cellulose fibers to be bound in a matrix.

Thermoplastic materials are the preferred binders, and can be combined with the fibers in the form of particles, emulsions, or as fibers. Suitable fibers can include those made from thermoplastic polymers, cellulosic or other fibers coated with thermoplastic polymers, and multicomponent fibers in which at least one of the components of the fiber comprises a thermoplastic polymer. Single and multicomponent fibers are manufactured from polyester, polyethylene, polypropylene and other conventional thermoplastic fiber materials. The same thermoplastics can be used in particulate or emulsion form. Many single component fibers are commercially available. Suitable multicomponent fibers include Celbond® fibers, a bicomponent fiber, available from Hoechst Celanese Company. Suitable coated fibers can include cellulose fibers coated with latex or other thermoplastics, as disclosed in U.S. Patent No. 5,230,959, issued July 27, 1993, to Young et al., and U.S. Patent No. 5,064,689, issued November 12, 1991, to Young et al. The thermoplastic fibers are preferably combined with the cellulose fibers before or during the laying process. When used in particulate or emulsion form, the thermoplastics can be combined with the cellulose fibers before, during, or after the laying process.

Other suitable thermoplastic bonding agents include ethylene vinyl alcohol, polyvinyl acetate, acrylics, polyvinyl acetate acrylate, polyvinyl dichloride, ethylene vinyl acetate, ethylene vinyl chloride, polyvinyl chloride, styrene, styrene acrylate, styrene butadiene, styrene acrylonitrile, butadiene acrylonitrile, acrylonitrile butadiene styrene, ethylene acrylic acid, urethanes, polycarbonate, polyphenylene oxide, and polyimides.

Thermosetting materials also serve as excellent bonding agents for the present invention. Typical thermosetting materials are activated by heating to elevated

temperatures at which crosslinking occurs. Alternatively, a resin can be activated by combining it with a suitable crosslinking catalyst before or after it has been applied to the cellulosic fiber. Thermosetting resins can be deactivated by allowing the crosslinking process to run to completion or by cooling to room temperature, at which point crosslinking ceases. When crosslinked, it is believed that the thermosetting materials form a matrix to bond the cellulose fibers. It is contemplated that other types of bonding agents can also be employed, for example, those that are activated by contact with steam, moisture, microwave energy, and other conventional means of activation.

Thermosetting bonding agents suitable for the present invention include phenolic resins, polyvinyl acetates, urea formaldehyde, melamine formaldehyde, and acrylics. Other thermosetting bonding agents include epoxy, phenolic, bismaleimide, polyimide, melamine formaldehyde, polyester, urethanes, and urea.

These bonding agents are normally combined with the fibers in the form of an aqueous emulsion. They can be combined with the fibers during the laying process. Alternatively, they can be sprayed onto a loose web after it has been formed.

As noted above, the binder utilized in accordance with the present invention can also be a soluble bonding medium that can be incorporated with the pulped cellulosic fibers, either in fiber form, or as particles or granules. If desired, the bonding medium can also be coated onto solvent insoluble fibers, such as cellulosic fibers, which can then be distributed throughout the matrix of pulped cellulosic fibers. It is presently preferred that the bonding medium comprise a fiber and be mixed with the pulped cellulosic fibers during, for example, the formation of a fluff web by conventional air-laid processes. The use of soluble bonding mediums with cellulose fiber webs is disclosed in U. S. patent application Serial No. 08/669,406, filed July 3, 1996, entitled "Fibrous Web Having Improved Strength and Method of Making the Same," expressly incorporated herein by reference.

The solvents employed in accordance with the present invention must of course be capable of partially solubilizing the bonding medium as described above. The solvents must be able to partially dissipate or migrate from the surface of the bonding medium to allow the bonding medium to resolidify after partial solubilization. Nonvolatile solvents may be dissipated in most part by absorption into the bonding medium. It is preferred that the solvent be of limited volatility, so that little or no solvent will be lost to the atmosphere. By limited volatility it is meant that the solvent has a vapor pressure of 29 kPa or less at 25°C. Using a solvent of limited volatility

may mitigate precautions usually necessary to control volatiles, and reduces the amount of solvent required to partially solubilize the bonding medium. In addition, use of solvents of limited volatility may eliminate the attendant processing problems encountered with volatile solvents, many of which are flammable and must be handled with care. The use of solvents of limited volatility may also reduce environmental problems. Furthermore, it is desirable for solvents to be nontoxic and capable of being dissipated from the surface of the bonding medium without adversely affecting the overall strength of the bonding medium.

Preferred bonding mediums and solvents of limited volatility are listed in the table set forth below.

Bonding Medium	Solvent
cellulose acetate	triacetin
	propane diol diacetate
	propane diol
	dipropionate
	propane diol dibutyrate
	triethyl citrate
	dibutyl phthalate
cellulose nitrate	triacetin
cellulose butyrate	triacetin
vinyl chloride/vinyl acetate copolymer	triacetin
cellulose fibers coated with polyvinyl acetate	triacetin

Of the several bonding mediums listed, cellulose acetate is the most preferred. During manufacture of cellulose acetate fibers, a finish is usually applied to the fibers. Many times this finish is in the form of an oil. The presence of the finish sometimes detracts from the performance as a bonding medium. The presence of a finish may adversely affect the development as well as the strength of the bonds. It has been found that when the bonding fibers are as straight as possible, as opposed to curled or kinked, they provide more contact points with the cellulosic fibers, and thus the final web will develop better strength. Similarly, when the bonding fibers are as long as is reasonably possible, the strength of the final web is increased. In addition to the

foregoing, cellulose ethers and other cellulose esters may also be used as bonding medium. Acetylated pulp fibers may also be used as bonding medium and may be substituted with any number of acetyl groups. A preferred degree of substitution (D.S.) would be 2 to 3, and a most preferred D.S. would be 2.4.

The solvents used in combination with the bonding medium can be added in varying amounts. Strength is adversely affected if too little or too much solvent is added. At a cellulose acetate/pulp weight ratio of 10:90, it has been found that the solvents, and particularly triacetin, provide good strength when added in amounts ranging from 6% to 17%, and most preferably in the range of 9% to 14%, based on the weight of pulp fiber present.

The preferred forms of the solvents propane diol diacetate, dipropionate, and dibutyrate are the 1,2 and 1,3 forms. Other suitable solvents that work in accordance with present invention are butyl phthalyl butyl glycolate, N-cyclohexyl-p-toluenesulfonamide, diamyl phthalate, dibutyl phthalate, dibutyl succinate, dibutyl tartrate, diethylene glycol dipropionate, di-(2-ethoxyethyl) adipate, di-(2-ethoxyethyl) phthalate, diethyl adipate, diethyl phthalate, diethyl succinate, diethyl tartrate, di-(2-methoxyethyl) adipate, di-(2-methoxyethyl) phthalate, dimethyl phthalate, dipropyl phthalate, ethyl o-benzoylbenzoate, ethyl phthalyl ethyl glycolate, ethylene glycol diacetate, ethylene glycol dibutyrate, ethylene glycol dipropionate, methyl o-benzoylbenzoate, methyl phthalyl ethyl glycolate, N-o and p-tolylethylsulfonamide, o-tolyl p-toluenesulfonate, tributyl citrate, tributyl phosphate, tributyrin, triethylene glycol diacetate, triethylene glycol dibutyrate, triethylene glycol dipropionate, and tripropionin.

Preferably, the binder is integrally incorporated into or onto the hydrophilic fibrous web that is formed in the production of the unitary absorbent layer. The binder can be added to pulp prior to web formation, by applying the binder to the air-laid web after web deposition, after drying, or a combination thereof.

Additives can also be incorporated into an unitary absorbent layer of the present invention during layer formation. The advantage of incorporating the additives during composite formation is that they will also be attached to the acquisition matrix by certain of the solvents and bound in the matrix by the bonding medium. This provides a significant advantage in that the additives can be dispersed and retained throughout the matrix where desired. For example, the additives may be evenly dispersed and retained throughout the matrix. Additives that can be incorporated into the matrix include absorbent capacity enhancing materials such as

superabsorbent polymers, adsorbents such as clays, zeolites and activated carbon, brighteners such as titanium oxide, and odor absorbents such as sodium bicarbonate. Solvents can also reduce the dusting caused by the additives or the pulp itself because more of the fines are attached and bound to the matrix by the bonding medium.

In another aspect, the present invention provides a method for producing a unitary absorbent layer. The unitary absorbent layer of the present invention can be formed by an air-laid process including, for example, air-laid web forming techniques known to those of ordinary skill in the pulp processing art. Representative examples of air-laid processes are disclosed in U.S. patent applications: Serial No. 08/337,642, filed November 10, 1994, entitled "Densified Cellulose Fiber Pads and Methods of Making the Same," and Serial No. 08/669,406, filed July 3, 1996, entitled "Fibrous Web Having Improved Strength and Method of Making the Same," both expressly incorporated herein by reference.

The unitary absorbent layer of the present invention generally has a basis weight from about 10 to about 1500 g/m^2, and preferably from about 20 to about 500 g/m^2. In a more preferred embodiment, the absorbent layer has a basis weight in the range from about 40 to about 400 g/m^2.

The absorbent layer of the invention is useful as an acquisition layer, which preferably has a low density for rapid liquid acquisition. Thus, the unitary absorbent layer is preferably an undensified layer. Generally, the unitary absorbent layer has a density from about 0.02 to about 0.2 g/cm^3, and preferably from about 0.04 to about 0.10 g/m^3.

The absorbent layer of this invention effectively bonds the fibers of the layer. The bonding is such that a representative layer formed in accordance with the present invention increases in density from about 0.04g/cm^3 (dry density) to about 0.08 g/cm^3 (wet density) on liquid acquisition.

Because the unitary absorbent layer of the invention is preferably an undensified layer, production methods used in connection with the absorbent layer preferably do not include subjecting the absorbent layer, or absorbent articles that incorporate the absorbent layer, to densification conditions. For example, in the production of diapers that incorporate the absorbent layer of the present invention, the absorbent layer is preferably incorporated into the diaper after the diaper has been subjected to the application of pressure such as, for example, being passed through a calender roll.

The unitary absorbent layer can be produced in a number of forms including sheets and rolls, and having a variety of thicknesses.

The unitary absorbent layer of the invention is generally characterized as having increased wet integrity (i.e., increase resistance to wet collapse) compared to conventional acquisition layers. The increased wet pad integrity of the absorbent layer of this invention prevents wet collapse and tearing of the composite during liquid insult and thereby avoids leakage during insult from absorbent articles that incorporate the acquisition layer.

The unitary absorbent layer of the invention also has increased pore size uniformity compared to conventional acquisition layers. The composite's uniform pore size is maintained during liquid insult and thereby effectively facilitates transport and distribution of the acquired liquid from the point of initial insult to other portions of the composite and, ultimately, to the absorbent article's core or permanent storage layer where the liquid is finally absorbed.

Depending upon the nature of the absorbent construct, an absorbent article incorporating the unitary absorbent layer may include one or more additional layers, such as a core layer (i.e., permanent storage layer) (see, for example, FIGURES 3-5). In such a construct, in addition to rapidly absorbing the acquired liquid, the layer has absorbent capacity sufficient to temporarily hold the acquired liquid and therefore provide time sufficient for the core layer to permanently absorb liquid from the layer.

As noted above, the unitary absorbent layer can be incorporated in an absorbent article as an absorbent acquisition/distribution layer. The absorbent layer can be used alone, or as illustrated in FIGURE 1, can be used in combination with one or more secondary layers. In FIGURE 1, unitary absorbent layer 10 is employed as an upper acquisition/distribution layer in combination with a storage layer 20 composed of, for example, a fibrous web. Storage layer 20, if desired, can also comprise a densified layer of bonded cellulose fibers. As illustrated in FIGURE 2, a third layer 30 (e.g., a core or retention layer) can also be employed, if desired, with a storage layer 20 and unitary absorbent layer 10. If desired, the retention layer 30 can also be composed of a fibrous web such as, for example, densified bonded cellulose fibers.

A variety of suitable constructs can be produced from the unitary absorbent layer. The most common include absorptive consumer products such as diapers, feminine hygiene products such as feminine napkins, and adult incontinence products. For example, referring to FIGURE 3, an absorbent article 40 comprises unitary

absorbent layer 10 and an underlying storage layer 20. A liquid pervious facing sheet 16 overlies unitary absorbent layer 10, and a liquid impervious backing sheet 18 underlies the storage layer 20. The unitary absorbent layer will provide advantageous liquid acquisition performance for use in, for example, diapers. The capillary structure (i.e., pore size, pore size uniformity, and permeability) of the acquisition layer will aid in fluid transport in multiple wettings. Generally, the storage layer 20 includes a fibrous web, for example, a strengthened web of cellulose fibers, and may also incorporate additives, such as superabsorbent polymers to significantly increase the absorbent capacity of the storage layer 20.

The article of FIGURE 3 can be assembled such that unitary absorbent layer 10 is brought into contact with the storage layer 20 while the binder in the latter is still active. Such a procedure will allow the storage layer to bond to at least the lower surface of layer 10, and thus eliminate the need to use hot melt glues to bond adjacent layers.

A stronger bond between layer 10 and the storage layer 20 can be achieved by contacting the layer with the storage layer while the layer's binder is still active. Similarly, laying the storage layer 20 on the backing sheet 18 while the binder of the storage layer is still active results in the bonding of layer 20 to the backing sheet 18. In a similar manner, layer 10 may be bonded to the facing sheet 16 by laying the facing sheet on layer 10 while the binder therein is still active. Interbonding between layers can generally enhance and further facilitate fluid transport across the layer interface.

The construct in FIGURE 3 is shown for purposes of exemplifying a typical absorbent article, such as a diaper or feminine napkin. One of ordinary skill will be able to make a variety of different absorbent constructs using the concepts taught herein. For example, a typical construction for an adult incontinence absorbent structure is shown in FIGURE 4. The article 50 comprises a facing sheet 16, unitary absorbent layer 10, a storage layer 20, and a backing sheet 18. The facing sheet 16 is pervious to liquid while the backing sheet 18 is impervious to liquid. In this construct, a liquid pervious tissue 22 composed of a polar, fibrous material is positioned between layer 10 and storage layer 20.

Referring to FIGURE 5, another absorbent article includes a backing sheet 18, a storage layer 20, an intermediate layer 24, unitary absorbent layer 10, and a facing sheet 16. The intermediate layer can be incorporated into the article to increase the article's integrity or as a distribution layer to enhance the distribution of liquid from

the acquisition layer to the storage layer. The intermediate layer 24 contains, for example, a densified fibrous material such as a combination of cellulose acetate and triacetin, which are combined just prior to forming the article. The intermediate layer 24 can thus bond to both the unitary absorbent layer 10 and the storage layer 20 to form an absorbent article having significantly more integrity than one in which the unitary absorbent layer and storage layer are not bonded to each other. The hydrophilicity of layer 24 can be adjusted in such a way as to create a hydrophilicity gradient among layers 10, 24 and 20. It should be understood that an independent intermediate layer is not required in order to get layer to layer bonding. When one of two adjacent layers or both layers contain a binder, if the two layers are brought together when the bonding medium is still active, bonding between the two layers will occur and provide a stronger composite compared to a composite lacking any bonding.

The unitary absorbent layer of the present invention improves the wet and dry integrity, surface dryness, rewet performance, and acquisition rate of absorbent products and articles that incorporate the absorbent layer. The unitary absorbent layer also provides increased pad integrity, improved appearance, and a reduction in wet collapse during use for absorbent products that incorporate the composite. Furthermore, because the unitary absorbent layer can be manufactured and delivered in web form, absorbent product manufacturing processes that include the absorbent layer are simplified relative to manufacturing processes that involve the handling of bales of crosslinked fibers or fluff pulp.

The following example is provided for the purpose of illustration, and not limitation.

EXAMPLE

Unitary Absorbent Layer Formation

This example illustrates a method for forming a representative unitary absorbent layer of the present invention. In this example, the unitary absorbent layer is composed of 85% crosslinked cellulose fibers (Weyerhaeuser Co.) and 15% Danaklon® (a polypropylene polyethylene bicomponent fiber commercially available from Danaklon, Inc.).

Fiber Preparation

Crosslinked cellulose fibers and Danaklon® were placed in a plastic bag and mixed thoroughly with an air stream.

Sheet Formation

A pinmill was used to "open" the fibers. The resulting fibers were then evenly distributed on a tissue by slowly metering the addition of the crosslinked cellulose fiber- Danaklon® mixture into the air former.

The representative unitary absorbent layer was produced by placing the resulting air sheet in a through air dryer to effect bonding.

While the preferred embodiment of the invention has been illustrated and described, it will be appreciated that various changes can be made therein without departing from the spirit and scope of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An air-laid absorbent layer comprising crosslinked cellulosic fibers and a binder, wherein the layer is an undensified layer.

2. The absorbent layer of Claim 1 wherein the crosslinked cellulosic fibers are present in an amount from about 5 to about 95 percent by weight of the total composite.

3. The absorbent layer of Claim 1 further comprising noncrosslinked cellulose fibers.

4. The absorbent layer of Claim 1 further comprising synthetic fibers.

5. The absorbent layer of Claim 1 wherein the synthetic fibers are selected from the group consisting of polyethylene terephthalate, polyethylene, polypropylene, nylon, and rayon fibers.

6. The absorbent layer of Claim 1 wherein the synthetic fibers have a length up to about 0.75 inch.

7. The absorbent layer of Claim 1 wherein the synthetic fibers have a length from about 0.25 to about 0.50 inch.

8. The absorbent layer of Claim 1 wherein the synthetic fibers have a denier from about 5 to about 20.

9. The absorbent layer of Claim 1 wherein the synthetic fibers are crimped fibers.

10. The absorbent layer of Claim 1 wherein the binder is present in an amount up to about 30 percent by weight of the total composite.

11. The absorbent layer of Claim 1 wherein the bonding agent is selected from the group consisting of thermoplastic and thermosetting bonding agents.

12. The absorbent layer of Claim 11 wherein the thermoplastic bonding agent is a multicomponent binding fiber.

13. The absorbent layer of Claim 1 wherein the absorbent layer has a basis weight from about 40 to about 400 g/m^2.

14. The absorbent layer of Claim 1 wherein the absorbent layer has a density from about 0.04 to about 0.10 g/m^3.

15. The absorbent layer of Claim 1 wherein the absorbent layer has substantially uniform pore size.

16. The absorbent layer of Claim 1 further comprising a superabsorbent polymeric material.

17. An air-laid absorbent layer comprising crosslinked cellulose fibers and multicomponent binding fibers, wherein the layer is an undensified layer.

18. The absorbent layer of Claim 17 wherein the crosslinked fibers are present in an amount from about 70 to about 90 percent by weight of the total fibers.

19. The absorbent layer of Claim 17 wherein the multicomponent binding fibers are present in an amount from about 10 to about 30 percent by weight of the total fibers.

20. The absorbent layer of Claim 17 further comprising polyethylene terephthalate fibers.

21. The absorbent layer of Claim 17 wherein the crosslinked fibers and binding fibers are thermally bonded.

22. An absorbent article comprising an air-laid absorbent layer comprising crosslinked cellulosic fibers and a binder, wherein the layer is an undensified layer.

23. An absorbent article comprising:

(a) a liquid pervious topsheet;

(b) an air-laid absorbent layer comprising crosslinked cellulosic fibers and a binder, wherein the layer is an undensified layer; and

(c) a liquid impervious backsheet.

24. An absorbent article comprising:

(a) a liquid pervious topsheet;

(b) an air-laid absorbent layer comprising crosslinked cellulosic fibers and a binder, wherein the layer is an undensified layer;

(c) a storage stratum comprising an absorbent fibrous material; and

(d) a liquid impervious backsheet.

25. An absorbent article comprising:

(a) a liquid pervious topsheet;

(b) an air-laid absorbent layer comprising crosslinked cellulosic fibers and a binder, wherein the layer is an undensified layer;

(c) a storage layer comprising an absorbent fibrous material;

(d) an intermediate layer interposed between the absorbent layer and the storage layer; and

(e) a liquid impervious backsheet.

26. The absorbent article of Claim 25 wherein the intermediate layer comprises a liquid pervious tissue.

27. The absorbent article of Claim 25 wherein the intermediate layer comprises a distribution layer.

28. The absorbent article of Claim 27 wherein the distribution layer comprises hydrophilic fibers and a binder.

29. The absorbent article of Claim 28 wherein the hydrophilic fibers comprise crosslinked cellulosic fibers.

30. The absorbent article of Claim 27 wherein the distribution layer further comprises superabsorbent polymeric material.

31. The absorbent article of Claim 23 wherein the article is a feminine care product.

32. The absorbent article of Claim 24 wherein the article is a diaper.

33. The absorbent article of Claim 26 wherein the article is an incontinence product.

34. The absorbent article of Claim 27 wherein the article is a diaper.

35. A method for forming an unitary absorbent layer comprising the steps of:

combining crosslinked cellulosic fibers and a binder to provide a fibrous mixture;

depositing the fibrous mixture on a foraminous support to provide a fibrous composite; and

heating the fibrous composite to effect thermal bonding between the fibers and binder to provide a unitary absorbent layer.

36. The method of Claim 35 wherein the binder is a bonding agent.

37. The method of Claim 36 wherein the bonding agent is a thermoplastic bonding agent.

38. The method of Claim 37 wherein the thermoplastic bonding agent is a multicomponent binding fiber.

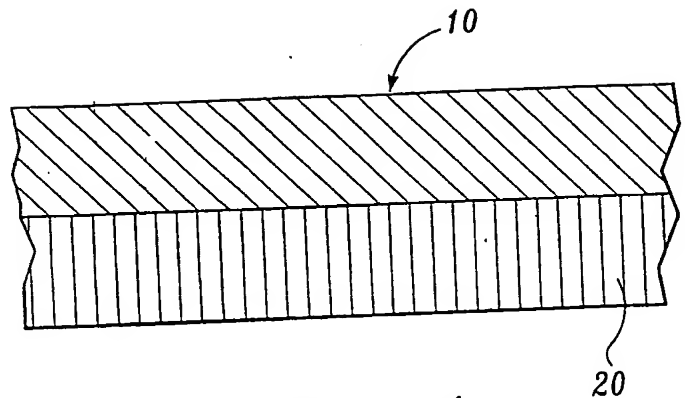

Fig. 1.

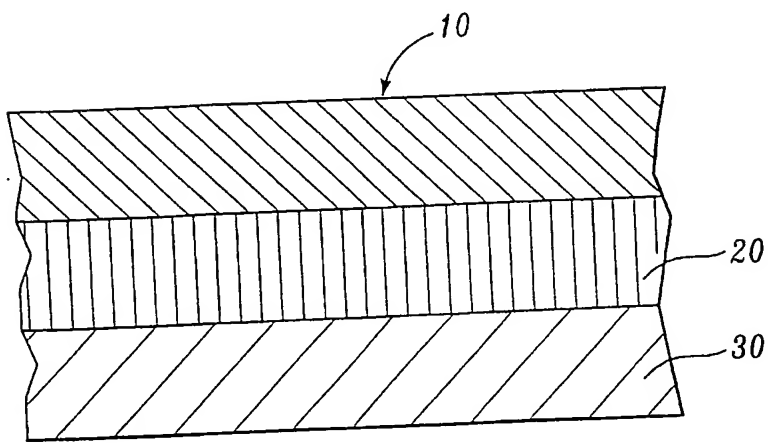

Fig. 2.

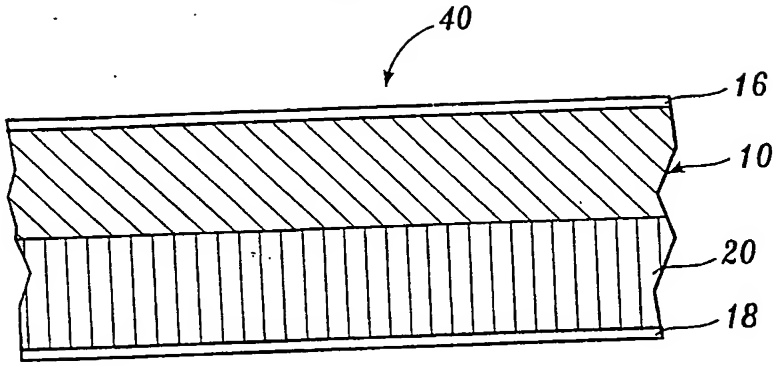

Fig. 3.

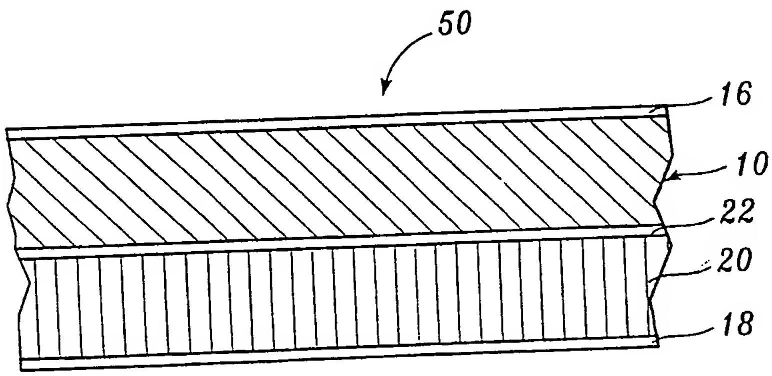

Fig. 4.

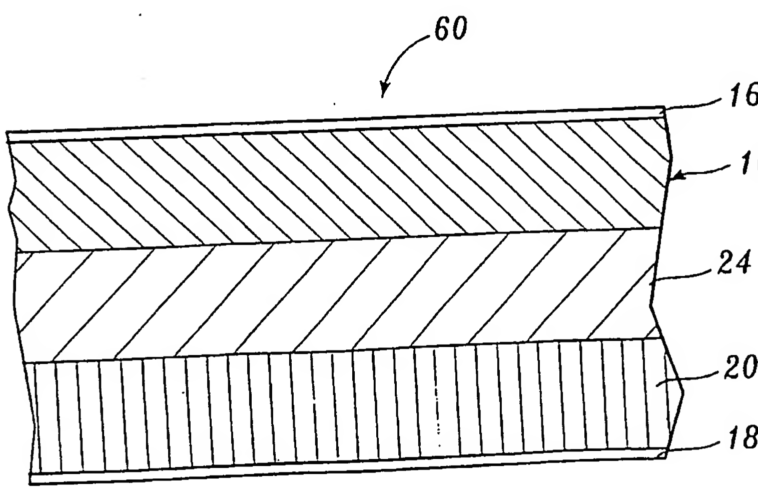

Fig. 5.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 97/23152

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 D04H1/54 D04H1/60 A61F13/15

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 D04H A61F A61L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 437 418 A (GRAEF PETER A ET AL) 1 August 1995 see column 21, line 40 - column 22, line 50; figure 16 ---	1,4,11, 12,17, 21,35-38
A	US 5 057 166 A (YOUNG SR RICHARD H ET AL) 15 October 1991 cited in the application see column 4, line 40 - column 9, line 6 see column 17, line 5 - line 11 see column 13, line 66 - column 14, line 29 ---	1-38
A	EP 0 394 812 A (WEYERHAEUSER CO) 31 October 1990 see the whole document ---	1-38

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

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Date of the actual completion of the international search	Date of mailing of the international search report
15 April 1998	24/04/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Barathe, R

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	WO 96 27703 A (WEYERHAEUSER CO ;HALABISKY DONALD D (US); WEST HUGH (US); HAJNAL A) 12 September 1996 see figures 3-5 -----	1-38

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Information on patent family members

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